

The validity of the mobile gamification in economic subject

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ABSTRACT

Mobile gamification has shown growing adoption in education, demonstrating potential to enhance engagement and learning outcomes. This study addresses challenges in economics education, including moderate student achievement, reliance on teachers, and lack of student motivation. To tackle these issues, a mobile gamification tool was developed for secondary school economics. The study's objective was to validate the content and educational relevance of this tool. Using a sequential exploratory mixed-method design, the research comprised two phases. First, focus group discussions (FGD) were conducted with seven economics and technology experts to assess the tool's interface and educational content. In the second phase, a content validity index (CVI) assessment quantified expert agreement on five key content areas. Results indicated a high level of expert consensus, with CVI values ranging from 0.87 to 1.00. These findings demonstrate that the gamified mobile tool is a valid educational resource that aligns with curriculum standards and can enhance student engagement in economics. The study concludes that mobile gamification is an effective strategy to support Economics education, encouraging self-directed learning and classroom interaction.

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1. INTRODUCTION

A recent trend among mobile phone users is mobile gamification. The fact that the user base grows annually suggests that the current generation is interested in mobile gamification. In Malaysia, the percentage of people who use a mobile phone has also increased to 94.8%, and 46.3% of study participants said they use their phones for gaming [1]. These figures demonstrate the need for the establishment of a new educational approach that makes use of mobile gamification. The term “gamification” describes the process of turning non-gaming activities into formal, structured game activities [2]. The concept of gamification aligns with the use of game-based elements such as reward systems, structured challenges, and narrative frameworks in non-gaming environments, functioning as a pedagogical strategy to enhance learner engagement and active participation [3], [4]. Rather than being limited to serious video games, the term gamification refers to instructional games [5]. Because it makes use of mobile phones, mobile gamification is therefore more focused on mobile devices than video games. Mobile operating systems like the Apple App Store, Google Play Store, Windows Phone Store, and other operating systems run in accordance with mobile phone brands must support mobile gamification [6]. With the growing interest in educational technology, mobile

gamification is gaining traction as a strategy to enhance learning experiences. Although distinct from traditional mobile games, mobile gamification leverages game-like elements in educational contexts, contributing to the increasing global investment in mobile-based educational tools, which is expected to surpass US\$173.60 billion in revenue by 2023.

The proliferation of mobile phone models is paralleling the development of mobile gamification in education. In the field of education, mobile gamification is an innovation that teachers must accept. Hoy [7] contends that educators ought to continuously innovate in the classroom. They must use strategies that are appropriate for the cultural background, personal preferences, and skill levels of each student. One such approach that fits in with current trends and is regarded as student-centered learning is learning through mobile gamification. Because students can learn with little assistance from teachers, student-centered learning is thought to be of a higher caliber. It is thought that teachers are properly cultivating their students when they get them involved in the process of seeking meaningful knowledge [8]. This is especially helpful when the current curriculum incorporates the trend of information and communication technology (ICT) [8]. Additionally, pupils' cognitive abilities may be impacted by the use of mobile gamification in the classroom [9]. This is in line with the main objectives of the Malaysian Education Blueprint 2013-2025, which is to use ICT to improve learning in Malaysia. Through a number of agencies, the Ministry of Education (KPM) has been investigating how multi-modal learning models, which make use of technology, can improve students' learning.

The original application of gamification in education sought to address a number of problems with the educational framework [3]. When employing games in the classroom, gamification allows students' accomplishments to fluctuate in tandem with their motivation. Continuous learning is more enjoyable in addition to being more motivating [10]. Additionally, students can become more productive and enhance students' level of reading [11]. Mobile gamification exercises can improve learning sessions if they are designed according to suitable learning models and are geolocated accurately [12]. These studies show that gamification can, in fact, significantly improve students' learning outcomes. The allure of mobile gamification encourages students to continue being involved in their education. These games are appealing because they incorporate different media elements, like graphics [13]. The competitiveness, eye-catching graphics, and entertaining elements all contribute to the game design's perceived attractiveness [14].

Although this mobile game has proven effective, its implementation for economics in high schools remains limited [15] compared to other subjects. For example, there are mobile gamification for chemistry subject [16], and mathematics subject [17]. For instance, a study on the application of mobile game techniques to math learning revealed that the learning goals were met by these games [18]. Gamification can help achieve even the most difficult learning objectives [9]. Parents and students responded favorably to studies on the creation of the mobile math game "Sifir Run" for the purpose of teaching multiplication to elementary school pupils [17]. Games for biology classes are intended to refocus students' attention toward voluntarily studying biology, claim Shapri and Ahmad [19]. This effect can last over an extended period of time in addition to being seen in the short term [20].

Despite the surge in online learning methods post-COVID-19, such as Google Meet and Zoom, student reliance on teachers during the teaching and learning process remains high [21]. Interestingly, students are already equipped with the necessary devices and internet connectivity for self-directed learning at home [13]. Moreover, gamification in learning through digital mobile devices is increasingly regarded as an effective instructional approach for engaging the younger generation [22]. However, even with tools like the ITHINK (Mapping) application, which theoretically eliminates the need for teachers in learning, students still seek guidance from teachers when using it.

Although the COVID-19 pandemic has ended, the shift towards digital learning tools has left a lasting impact on education. The pandemic accelerated the adoption of online learning platforms, and mobile gamification has emerged as a valuable strategy for engaging students beyond the physical classroom. Mobile games for economics remain relevant today because they support a blended learning environment, providing flexibility for students to learn at their own pace, both in-person and online. Studies have shown that gamified tools can enhance student motivation, engagement, and retention of content in digital and hybrid educational settings [5]. Moreover, economics, with its theoretical concepts and data analysis, can benefit significantly from interactive and immersive learning experiences provided by gamification, making complex topics more accessible and enjoyable for students.

Furthermore, even though they were exposed to the gadget usage, students were not motivated to review their lessons at home, even though mobile phones and other technological resources were easily accessible [23]. Post-school learning holds significant importance nowadays, especially because students often lack sufficient time to review economics lessons during school hours. This approach aims to reinforce basic concepts by having students engage in further learning at home after initial explanations in class. While unconventional, this method demonstrates students' readiness in terms of knowledge, attitude, and motivation, as observed by Roziah *et al.* [24].

Additionally, secondary students who had recently been introduced to the subject of economics found it to be quite difficult [25]. This difficulty arises from the statistical nature of economics learning, involving numerous graphs and curves to understand. The subject also encompasses theoretical elements, analysis, and applications, making it challenging for teachers to enhance students' comprehension [26]. Students were also overly reliant on teachers during the learning process, even when online learning methods were implemented [27].

Due to this existing issues, a mobile game application has been developed for the economics subject. In crafting this game application, development guidelines were obtained through conducted document analysis. There are five guidelines: i) theoretical elements; ii) gamification elements; iii) mobile learning approach elements; iv) multimedia elements; and v) questions integrated into the game.

Theoretical elements outline three theories utilized in the game's development: behaviorism, cognitive, and constructivism. These theories are combined with gamification elements delineated by Ariani [28], including characters, levels, scores, leader boards, and badges. The mobile learning approach also delineates four aspects: pedagogical and educational, social and cultural, business and economic, and technical and quality. Additionally, gamification includes multimedia design elements and features thirty questions of varying difficulty levels to assess students' economic skills. These guidelines culminate in a gamified experience within the economics subject.

Despite developing this gamification according to guidelines, experts in technology and economics must validate the suitability of all these elements in game development. The primary objective of this study is to explore experts' opinions on the development of mobile gamification and validate its content within economics using the content validity index (CVI). The research questions of this study are:

- i) What are the experts' views on the content and design of this game?
- ii) How do experts perceive the suitability of this game for classroom application?
- iii) What is the consensus among experts regarding the outline for the content of mobile gamification in the economics subject?

Based on the study's findings, this game will be refined and utilized in economics education, particularly for high school students. This expert-validated game is considered a precise product believed to enhance the learning process.

2. RESEARCH METHOD

This study uses a sequential exploratory mixed research design. First, qualitative methods were used for the research, and then quantitative methods. The expert opinions on the well-thought-out intervention were investigated using the qualitative method. Conversely, the quantitative approach was used to gauge the degree of agreement among specialists about the content of the created intervention. In the first phase of this study, focus group discussion (FGD) will be used, and in the second, the CVI.

2.1. Mobile game

The mobile game developed for this study is specifically designed to support the economics curriculum for secondary school students, focusing on enhancing understanding of key economic concepts. The game integrates educational theories—behaviorism, cognitivism, and constructivism—to create an engaging and effective learning environment. It features several levels of gameplay, each corresponding to a particular economics topic, such as price elasticity of demand and supply, determinants of elasticity, and market structures. These topics are delivered through interactive game mechanics that include missions, quizzes, and problem-solving activities.

Gamification elements, such as points, levels, badges, and leaderboards, are incorporated to foster motivation and provide immediate feedback, encouraging students to progress through the content at their own pace. The game's interface includes visually appealing graphics and multimedia elements designed to maintain student interest and facilitate learning. To align with the mobile learning approach, the game is accessible on Android devices and structured to allow flexibility in use—whether in the classroom or for independent study at home. The content is developed in alignment with the curriculum and assessment standard document (DSKP) provided by the Ministry of Education in Malaysia, ensuring its relevance to the national education standards. Additionally, the game integrates adaptive learning components that adjust the difficulty of questions based on the student's performance, supporting personalized learning paths.

The mobile game also includes a variety of question formats, such as multiple-choice, matching tasks, and scenario-based problems that require analytical thinking, reinforcing students' comprehension of economic principles. Throughout the gameplay, economic scenarios are simulated, allowing students to apply theoretical knowledge to practical situations, enhancing experiential learning. Feedback from economics and technology experts was integral to refining the game's content and interface, ensuring that it not only meets educational objectives but also provides an engaging user experience. This carefully structured development

process aims to balance educational rigor with engaging gameplay, making complex economic concepts accessible to a diverse student population.

2.2. Sample of expert

In this study, the same experts will be involved in both phases. These experts aim to test the game and validate the game content that has been developed. The sample for this study is purposeful sampling because the selected sample possesses specific characteristics. In line with Marhamin *et al.* [27] recommendation which states that the selection of experts depends on the researcher to choose a sample that is useful and suitable to meet the research requirements. The number of experts involved in this phase is seven economics experts from the Kuala Lumpur and Selangor regions. Experts appointed in the Kuala Lumpur and Selangor areas for the convenience of the experts to gather in nearby locations to test the game and validate the content. To avoid bias in the selection experts, it is critical to set clear criteria based on expertise, qualifications, and experience, ensuring that the selection process is merit driven. A diverse panel of experts can help to reduce bias by combining a variety of opinions and backgrounds in economics subject.

According to Erdmann and Potthoff [29], the number of experts is limited to a maximum of eight because the more experts appointed, the more fatigued they become in debating or discussing the matters to be evaluated. Therefore, a total of seven experts is adequate for this phase. These experts are selected based on the criteria outlined in which are: i) knowledge and experience with the issues under investigation; ii) the ability and willingness to participate; iii) sufficient time to participate; and iv) effective communication skills. Hence, the appointed experts should possess a master's degree in economics education, have over ten years of experience in teaching economics, and be proficient in using mobile devices. Table 1 shows the demographic data of the experts.

Table 1. Demographic data of experts

Variable	Percentage (n=7)
Gender	Male 14% (n=1)
	Female 86% (n=6)
Age	35-45 28% (n=2)
	46-55 72% (n=5)
Ethnicity	Malay 72% (n=5)
	Chinese 14% (n=1)
	Indian 14% (n=1)
Level of education	Bachelor's degree 43% (n=3)
	Master's degree 57% (n=4)
Working experience (years)	10-20 28% (n=2)
	21-30 72% (n=5)
Types of profession	Education (teacher) 100% (n=7)

2.3. FGD

2.3.1. Data collection

The mobile economics game will be made available to experts via the Google Play Store operating system prior to the FGD. There will be a brief break before the FGD discussion starts. The gamification tool's face validity which is determined by a number of factors will be the main topic of discussion. User engagement is the first requirement. Questions regarding the mobile economics game's user interface or UI and the experiences of experts will be posed. The second criterion concerns how the intervention in the mobile game is perceived in relation to the economics subject's content. This standard seeks to verify whether the intervention is pertinent to the subjects being studied in school. The mobile economics game's accessibility and usability are the subject of the third criterion. Professionals will evaluate the game's difficulty and educational value. The last criterion is an open-ended one that looks for recommendations on how to make the intervention better.

2.3.2. Data analysis

This study employs thematic analysis following the recommendations [30]. The first step of thematic analysis involves converting the audio recordings of the interviews into verbatim transcripts. Subsequently, a data cleaning process within the verbatim text is carried out, which involves the removal of non-meaningful words, such as "aaa", "oh", and others. The next step is for the researcher to repeatedly read the verbatim transcript to understand the data's context in qualitative research [30]. The process begins by identifying initial themes deductively based on the listed criteria. This is followed by an inductive theme identification process that may emerge from the interview data. Subsequently, the themes are categorized into

more meaningful categories that align with the research context. The categorized themes are reviewed, and findings are then reported.

2.4. CVI

2.4.1. Data collection

The CVI will be calculated based on experts' assessments of the mobile gamification content. CVI calculation is a widely accepted method for assessing content validity by economics subject experts. Experts will be provided with a questionnaire during a meeting held at an agreed-upon location. Unlike the FGD method, which assesses gamification tools, CVI is more focused on measuring the degree of agreement on various elements. The assessment will cover five elements: theoretical elements, gamification elements, mobile learning approach elements, multimedia elements, and question content elements. Table 2 presents the outline for the content of mobile gamification in the economics subject.

Table 2. Outline for the content of mobile gamification in the economics subject

Section	Outline for the content of mobile gamification in the economics subject
Section A: theory	Behaviorism theory in gamification Cognitive theory in gamification Constructivism theory in gamification
Section B: gamification	Characters Levels Scores Leaderboards Badges
Section C: mobile learning approaches	Pedagogical and educational Social and cultural Business and economic Technical and quality
Section D: multimedia	Graphic display
Section E: question content	Price elasticity of demand topics Price elasticity of supply topics Determinants and significance of elasticity topics

2.4.2. Data analysis

The CVI Score will be assessed based on the aggregate score by each expert. A score of 1 will be assigned to items that are valid (scale 3 and 4), while a score of 0 (scale 1-2) will be given otherwise. The formula to be used is based on I-CVI. The proportion of content experts giving item a relevance rating of 3 or 4, where the measurement is calculated as the agreed items divided by the total number of experts involved [31]. This study involves seven experts. According to Lynn [32], if seven experts are involved and the obtained I-CVI is >0.83 , the element will be accepted, and vice versa [31]. The total I-CVI will be categorized according to the 5 sections. Additionally, the scale-level content validity index (S-CVI/Ave) will also be measured, aiming to obtain the relevance scale proportion by all experts. S-CVI/Ave will be calculated using the formula: the sum of I-CVI divided by the number of items. universal agreement (UA) score is given as 1 when the item achieves 100% agreement among experts; otherwise, the UA score is given as 0 [31].

3. RESULTS

3.1. Finding from FGD

Based on the discussions, several themes have been identified, namely the game interface, suitability for economic learning, and question content. These themes address the research question of exploring the experts' views on the face validity of this intervention. The first theme is the game interface. Experts believe that the interface, such as the font type and color, is very suitable and easy to read.

“The writing used is very suitable and easy to read even when playing the game.” (I2)

This statement is also supported by I4, I5, and I6. However, there are experts who suggest that the text at the beginning of the game should be changed from white to a more suitable color like black or dark brown.

“There is text written at the beginning of the game that needs to be changed from white to a clearer color because it appears less clear.” (I1)

This statement is also supported by I3. Still within the theme of the game interface, experts believe that the graphics built into this game are very attractive and can enhance students' motivation to learn in the classroom.

“The graphics developed are very appealing and suitable for their age.” (I2)

“The use of highlighted colors in the game is beautiful. This beautiful atmosphere will enhance students' motivation when playing and not make it boring.” (I5)

While experts are satisfied with the game interface, they suggest that the hero's name be changed to the name of global economics experts:

“It would be better if the character in the game is changed to a hero related to economics. We have many global economics figures like Keynes.” (I6)

After looking at the game interface, the next theme is related to suitability for economic learning. In this game, game elements are combined with elements of economic learning. Players need to complete game missions while also completing economic learning missions. Experts agree that the developed game is very suitable for economic learning, in line with the DSKP outlined by the KPM:

“Even though this material is in the form of a game, I feel it's suitable for economic learning, and the questions asked align with the requirements of DSKP.” (I1)

This statement is supported by all experts and is complemented by the opinion that the game is suitable for classroom use, but the KPM needs to allow students to bring mobile phones to school.

“I'm interested in bringing this game into the classroom, but we have limitations as not all schools participate in the Bring Your Own Devices (BYOD) program. Therefore, KPM needs to allow the bringing of mobile phones into the classroom to implement this game in the classroom learning process.” (I4)

As for the last theme, it is more related to the questions developed in conjunction with the game. The questions developed are based on the topics of elasticity contained in the economics subject. There are several corrections that need to be made. The first correction to be made is on questions that show price changes in table form.

“For question 3 in the topic of demand and supply elasticity, the phrase 'if the price increases from RM5 to RM6 needs to be added for clarity.’ (I6)

There are also answer choices that need to be changed, namely:

“The answer choices for questions 5 and 8 in the topic of demand elasticity need to be changed as there is no correct answer.” (I2)

Several sentences in the questions also need to be modified to avoid confusing students:

“For me, the third topic in question 6 needs to add 'low production cost' so that students understand the question's requirements.” (I3)

Overall, the objective of the FGD for this phase has been achieved to assess the experts' consensus on the face validity of mobile gamification in economics subject. All feedback and improvements will be adjusted as needed and considered.

3.2. Finding from CVI

After obtaining consensus from the FGD, the validation continued with the expert assessment of the content of mobile gamification in economic subject. The agreement values were formulated into the five sections established at the beginning of the study. As explained earlier, according to Lynn [32], if seven experts are involved, and the S-CVI obtained is >0.83 , the element will be accepted, and vice versa [31]. Therefore, based on the results of S-CVI/Ave and S-CVI/UA, it indicates that all content validity for mobile gamification in economics is accepted because the value for each item exceeds 0.83. Table 3 shows the summary of I-CVI results.

Table 3. Summary of I-CVI calculation based on sections

Items	Section				
	A 6 items	B 5 items	C 4 items	D 5 items	E 24 items
S-CVI/Ave	1	1	1	0.98	0.94
S-CVI/UA	1	1	1	0.86	0.84
Average proportion of items	1	1	1	0.98	0.94

4. DISCUSSION

To fully realize the potential of mobile gamification in teaching economics, a thorough validation process is essential. This study utilized face validation and expert assessment through FGD and CVI to confirm the quality and effectiveness of the developed mobile gamification tool. The results align with the research objectives, which focused on gathering expert feedback on the design and content of the gamified application for economics education.

The game interface demonstrated clarity in content, instructions, and embedded questions, which was positively acknowledged by experts. This clarity is crucial for maintaining student engagement, as confirmed by existing literature [19]. The inclusion of engaging graphics was particularly effective in sustaining interest, a finding consistent with previous studies, such as the “Sifir Run” game [17], which emphasized the role of multimedia elements like visuals in enhancing student motivation [13], [18]. The game’s design also integrated various multimedia components, which blended cognitive and emotional engagement through interactive and narrative elements, creating an immersive educational experience [33].

The educational content closely follows the current economics curriculum and was deemed suitable for classroom use. This alignment represents a notable step forward in educational practice, as supported by prior research [7]. Key components of the mobile gamification like educational theories, gamification elements, mobile learning strategies, and multimedia integration—received strong validation from experts. The study illustrates that gamification effectively promotes knowledge acquisition and experiential learning by simulating real-world contexts, thereby fostering greater student engagement and motivation [34]. Unlike traditional teacher-centered methods, which can diminish motivation [35], this gamified approach demonstrates how innovative educational tools can improve learning outcomes [36].

Difficult economic concepts became more accessible and engaging when embedded within a gamified framework [12]. By applying game design principles, such as points, levels, and leaderboards, the study showed a notable impact on student motivation and engagement. This finding echoes the broader literature, which highlights the benefits of gamification in enhancing educational performance, even in diverse and challenging environments [37], [38]. Gamification not only enhances academic skills but also supports the development of problem-solving, decision-making, and collaborative skills, thereby contributing to overall student growth [34].

The gamification elements, including scores, levels, and leaderboards, were well-received by evaluators. These features are known to boost motivation, user interaction, and social dynamics, aligning with past research on effective gamification strategies [39]. The integration of mobile learning further enhanced the flexibility of the educational tool, meeting established criteria for effective mobile educational applications. According to experts, the mobile game supports competency, autonomy, and connectivity, which are key to fostering user engagement and satisfaction [40].

The validation of the game’s educational content was consistent with established educational theories. The behaviorist approach, implemented through interactive missions, encouraged active learning and was effective in teaching key economics concepts, such as elasticity. These findings are consistent with studies indicating that interactive stimuli can improve learning outcomes [41], [42]. The cognitive theory was also applied, with the game incorporating memory recall, problem-solving, and critical thinking activities. Experts noted the effectiveness of multimedia elements in enhancing memory retention, thereby reducing cognitive load [43], [44]. The constructivist theory, which emphasizes learning through experience, was evident in the game’s focus on active, student-centered tasks, facilitating deeper understanding and critical thinking with minimal teacher intervention [45], [46].

Expert evaluation also confirmed the validity of the game’s notes and questions, which align with national economics curriculum standards. However, minor adjustments were suggested to enhance clarity and accessibility for students. This feedback process reflects the importance of innovation in teaching practices, demonstrating how gamified learning can enrich economics education [47]. The selection of experts—veteran educators with over a decade of experience in the field—strengthens the study’s validity, as they are well-qualified to evaluate both face and content validity of the tool [48]. Clear guidance was provided to experts for the assessment process, ensuring a comprehensive evaluation.

The findings from both FGD and CVI assessments indicate that the game’s interface and content meet educational standards, validating its effectiveness as a teaching tool for economics. Although the high

validity values confirm the game's potential, further research is needed to evaluate its impact on educational outcomes. Teachers can confidently use this tool in classrooms, supported by strong expert validation. This game offers flexibility for students, allowing them to engage with economics content beyond the traditional classroom setting. It also holds promise for broader application within the national education system, potentially serving as a model for gamified learning across diverse subjects.

Despite its success, this study had limitations. The purposive sampling method may introduce bias, and a limited number of experts were consulted. Expanding the sample to include a more diverse range of economics educators across Malaysia could strengthen future research. Additionally, the game's availability is currently restricted, as it is not accessible through the Apple Store. Nevertheless, this study provides a strong foundation, demonstrating the viability of mobile gamification in economics education. Although the focus was on economics, the content standards developed in this study can be adapted for other educational disciplines.

The validation of the mobile gamification tool underscores the potential for gamified education to transform traditional learning approaches. Future research should focus on expanding gamification applications across various subjects and educational levels, assessing scalability, accessibility, and practicality in diverse educational settings. Continuous refinement, driven by feedback from educators and students, will be crucial to maintaining the relevance and effectiveness of gamified learning tools.

5. CONCLUSION

In conclusion, the development of mobile gamification in the economics subject has successfully achieved both usability and content validity, as evaluated by experts. The sequential assessments conducted, starting with the FGD and followed by the CVI assessment, have indeed reached a high level of validity. This outcome is a result of the meticulous development process conducted by the researcher. However, the researcher needs to make the necessary adjustments following the guidelines provided by the experts. Based on this study, the development of this intervention program has the potential to serve as a guide for other researchers in developing and validating mobile gamification in various educational fields.

The findings from this study highlight the effectiveness of mobile gamification as an educational tool, specifically in the context of Economics education. One significant implication is the demonstrated alignment of mobile gamification with curriculum standards, making it a viable supplement to traditional teaching methods. This gamified approach enhances student engagement, motivation, and knowledge retention by integrating interactive and multimedia elements. Moreover, the validation process, involving expert evaluations and a high CVI, establishes a robust framework for assessing educational tools, underscoring the importance of thorough validation in content development.

The findings also suggest that such tools can contribute to self-directed learning, fostering an interactive learning environment that promotes both behavioral and cognitive development. However, the study's limitations, such as the reliance on purposive sampling and a relatively small expert group, highlight the need for broader validation across diverse contexts. Future research should focus on expanding the application of mobile gamification to other subjects and educational levels, exploring scalability and accessibility, and assessing long-term impacts on student achievement. Additionally, continued feedback from educators and students will be essential to refine the gamified content and ensure its relevance in evolving educational landscapes. This iterative development process can help build a more adaptive and inclusive educational environment that leverages the potential of digital innovations.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : Conceptualization

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author [MZAM], upon reasonable request

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